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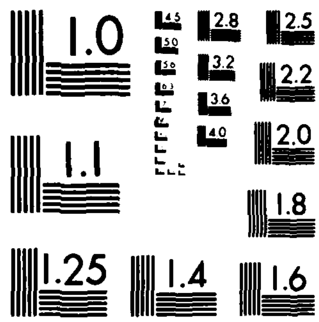

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AD-A145 873

R and D CENTER LABORATORY TECHNICAL REPORT

NO. 12950

RUBBER COMPOUND DEVELOPMENT
FOR IMPROVED MILITARY
TANK TRACK
PHASE I

December 1983

Contract DAAE07-83-C-R019

by The Goodyear Tire & Rubber Co
P. O. Box 288
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U.S. ARMY TANK-AUTOMOTIVE COMMAND
RESEARCH AND DEVELOPMENT CENTER
Warren, Michigan 48090

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NOTES

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT
Unlimited/Approved for public release

4. PERFORMING ORGANIZATION REPORT NUMBER(S)

5. MONITORING ORGANIZATION REPORT NUMBER(S)
12950

6a. NAME OF PERFORMING ORGANIZATION
Goodyear Tire & Rubber Co

6b. OFFICE SYMBOL *(If applicable)*

7a. NAME OF MONITORING ORGANIZATION
TACOM

6c. ADDRESS *(City, State, and ZIP Code)*
St Marys, OH 45885

7b. ADDRESS *(City, State, and ZIP Code)*
Warren, MI 48090

8a. NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL *(If applicable)*

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
DAAE07-83-C-R019

8c. ADDRESS *(City, State, and ZIP Code)*

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
-			

11. TITLE *(Include Security Classification)*
Rubber Compound Development for Improved Military Tank Track - Phase I

12. PERSONAL AUTHOR(S) Michael B Hoying

13a. TYPE OF REPORT
Final

13b. TIME COVERED
FROM 1-31-83 TO 5-31-84

14. DATE OF REPORT *(Year, Month, Day)*
1984 August

15. PAGE COUNT
21

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
Rubber, Compound, Track

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Ten each T-156 blocks were prepared from six different experimental compounds for analysis by TACOM. The compounds were formulated without regard for the requirements of Mil-T-11891B. These six compounds were chosen after laboratory testing of over 110 experimental formulations.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL

22b. TELEPHONE *(Include Area Code)*

22c. OFFICE SYMBOL

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1.0 INTRODUCTION

This report, prepared by The Goodyear Tire & Rubber Co under CLIN 0001 of contract DAAE07-83-C-R019, describes the development of experimental tank track compounds and subsequent molding of T-156 blocks for evaluation by TACOM.

2.0 OBJECTIVE

The objective of this work was to develop compounds for tank track service superior to those under current Mil-T-11891.

3.0 CONCLUSIONS

Ten each T-156 blocks were prepared from six different experimental compounds. Laboratory test results of these compounds show them superior in many ways over current Mil-T-11891 compounds. The experimental compounds were processed the same as other military tread compounds.

4.0 RECOMMENDATIONS

Each of the experimental compounds should be analyzed by TACOM in the laboratory and in field testing to see if the improvement in laboratory test results will give improved field test results.

5.0 DISCUSSION

5.1 Background

Current rubberized tank track provided under Mil-T-11891B has, in general, not given the desired mileage in field service. Work done under contract DAAE07-83-C-R019 was not subject to the requirements of Mil-T-11891B. It was felt that without the requirements of Mil-T-11891B, improved compounds could be generated.

So Goodyear has formulated six experimental compounds for analysis by TACOM. In accordance with the requirements of CLIN 0001, ten T-156 track blocks were produced from each of the experimental compounds and sent to TACOM for testing.

5.2 Materials

5.2.1 Road-side Rubber

The six formulations were chosen based on improvements in various areas over current Mil-T-11891B approved formulations. Final

formulations were arrived at after laboratory testing of over 110 formulations in the eight months since the contract was awarded. The six compounds were labeled A, B, C, D, E, and F.

5.2.2 Roadwheel Side Rubber

The rubber used for the roadwheel side of all the experimental blocks was SM8611. This compound has been used in regular production of T-156 track.

5.3 Testing

Results of the following tests were used to evaluate compounds throughout Phase 1. Results obtained on the six experimental compounds are presented and, where applicable, are discussed in relation to requirements of Mil-T-11891B.

All testing was done on laboratory cured specimens, not samples cut from finished parts.

5.3.1 Tensile Strength, Elongation, Tensile Modulus

The tensile strength, elongation and tensile modulus of the experimental compounds is presented in Table 5-1 and Figure 5-1. Compared to the Mil-T-11891B requirement of 2,900 psi, compounds B, C, D, E and F have substantially better tensile strengths. The tensile strength of compound A is 2,900 psi.

Elongation of the experimentals range from 459 percent to 550 percent compared to the Mil-T-11891 B minimum requirement of 400 percent. See Table 5-1 and Figure 5-2.

Tensile Modulus (also referred to as tensile stress) values are reported at both 100 percent and 400 percent elongation. This is a measure of the force needed to elongate the rubber to 100 percent and 400 percent elongation, see Table 5-1 and Figure 5-1.

The method used to determine Tensile strength, elongation and tensile modulus was ASTM D412.

5.3.2 Hardness

The hardness of the rubber, as determined by ASTM D2240, is reported in Table 5-1.

5.3.3 Tensile, Elongation, Tensile Modulus after 70 hrs/158 degrees Air Age

Samples were aged for 70 hrs at 158 degrees F in accordance with ASTM D573 and tested to get stress/strain properties. As shown in Table 5-1 and Figures 5-3 and 5-4, tensile strength, elongation and modulus show little change after aging 70 hrs at 158 degrees F. These compounds are stable when exposed to aging at 158 degrees F.

TABLE 5-1

Compound Properties

Compound	A	B	C	D	E	F	Mil-T-11891 B
Tensile (psi)	2900	3650	3725	2585	3440	3475	2900 Min
Elongation (percent)	550	541	465	459	459	498	400 Min
100 percent Modulus (psi)	380	380	580	530	540	550	
400 percent Modulus (psi)	2080	2675	3250	3170	2990	2810	2000 Min
Hardness (Shore A)	72	70	75	70	71	72	60 - 75
Specific Gravity	1.150	1.159	1.181	1.162	1.145	1.150	1.25
Die B Tear at 72 degrees F (lbs/in)	423	688	813	689	656	.675	300 Min
Die B Tear at 250 degrees F (lbs/in)	241	360	325	385	360	360	175 Min
Air Age 70 hrs/158 degrees F							
Tensile (psi) (percent retained)	2650 (91)	3550 (97)	3225 (86)	3370 (94)	3400 (99)	3450 (99)	2500
Elongation (percent)	420	515	393	418	433	482	300
100 percent Modulus (psi)	525	425	610	600	650	625	
400 percent Modulus (psi)	2525	2800	-	3225	3175	2900	
Hardness (Shore A)	80	70	76	73	75	75	
Air Age 70 hrs/212 degrees F							
Tensile (psi) (percent retained)	2620 (90)	3025 (83)	3000 (80)	2835 (79)	3000 (88)	3030 (87)	
Elongation (percent)	292	416	349	335	364	371	
100 percent Modulus (psi)	850	550	800	700	800	825	
Hardness (Shore A)	80	75	80	75	76	80	
Die B Tear at 72 degrees F (lbs/in)	291	679	690	514	478	552	
Die B Tear at 250 degrees F (lbs/in)	154	370	296	332	341	352	
Compression Set 22 hrs/158 degrees F (percent)	31.7	23.4	22.6	20.0	23.2	23.2	
Compression Set 22 hrs/212 degrees F (percent)	53.2	36.2	52.0	40.5	51.2	46.0	
-40 degrees Cold Test	OK	OK	OK	OK	OK	OK	
Seven Day Ozone Rating	0	0	0	0	0	0	

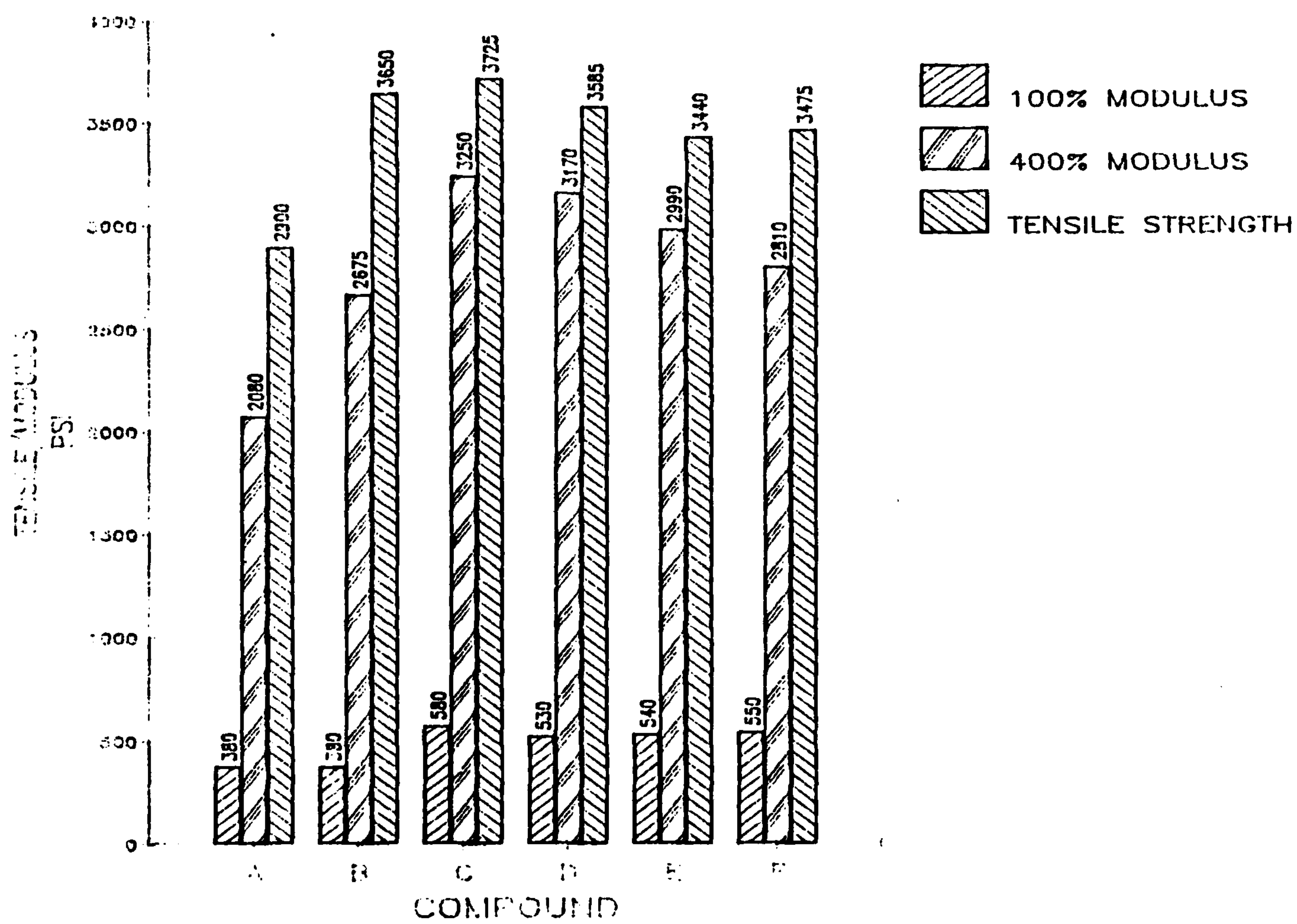

Figure 5-1 TENSILE AND MODULUS

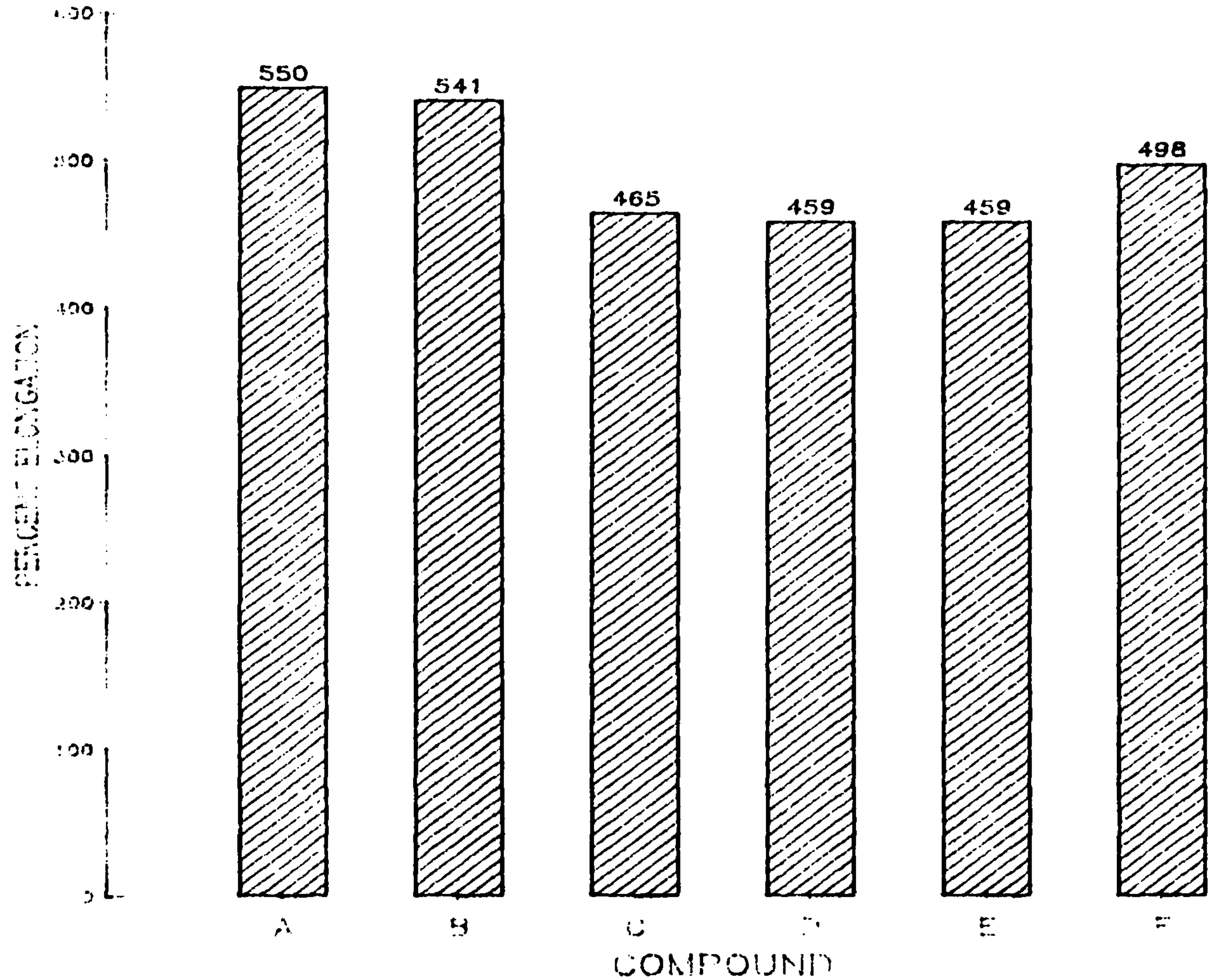

Figure 5-2 ELONGATION

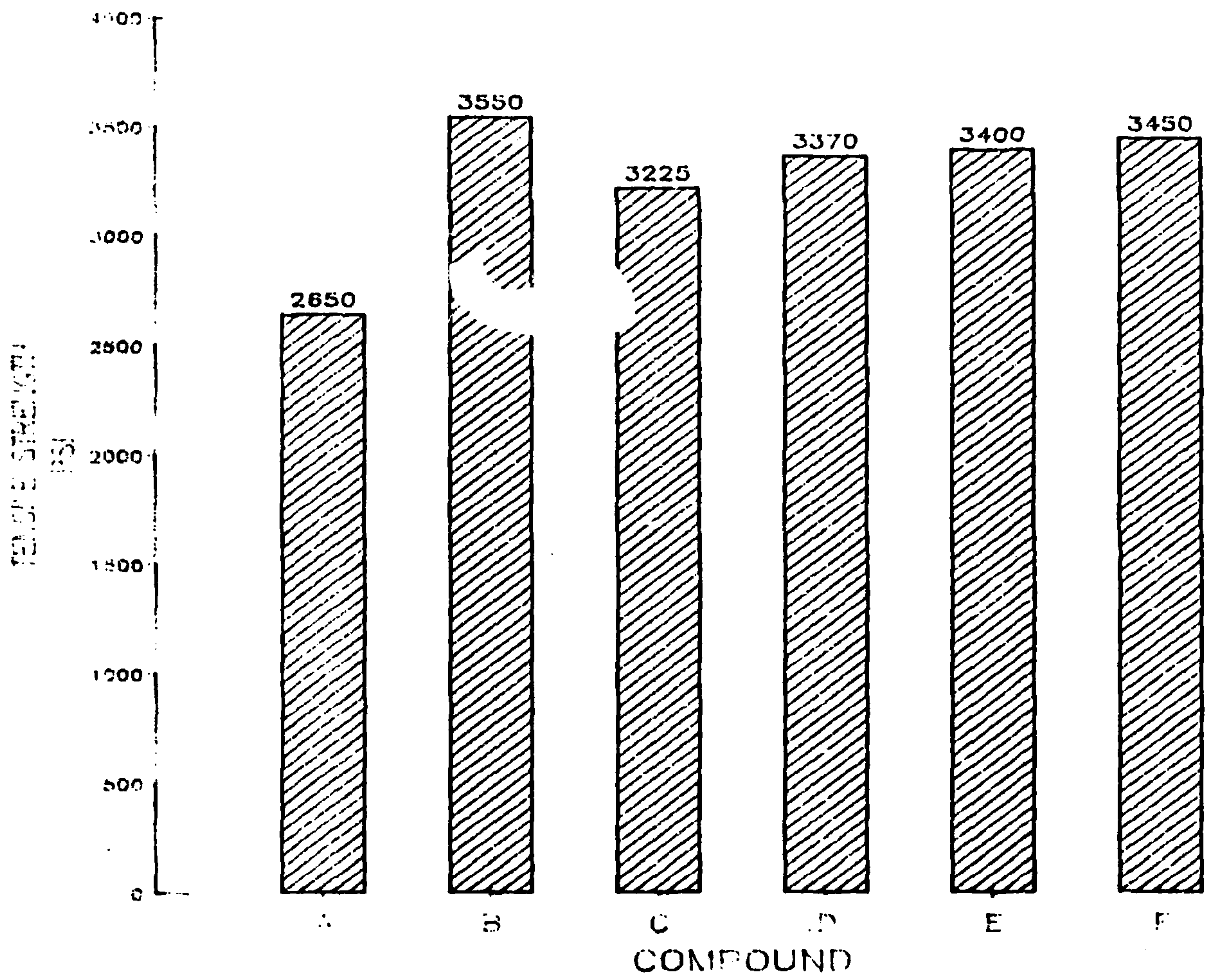

Figure 5-3 TENSILE STRENGTH AFTER 70/158 F AIR AGE

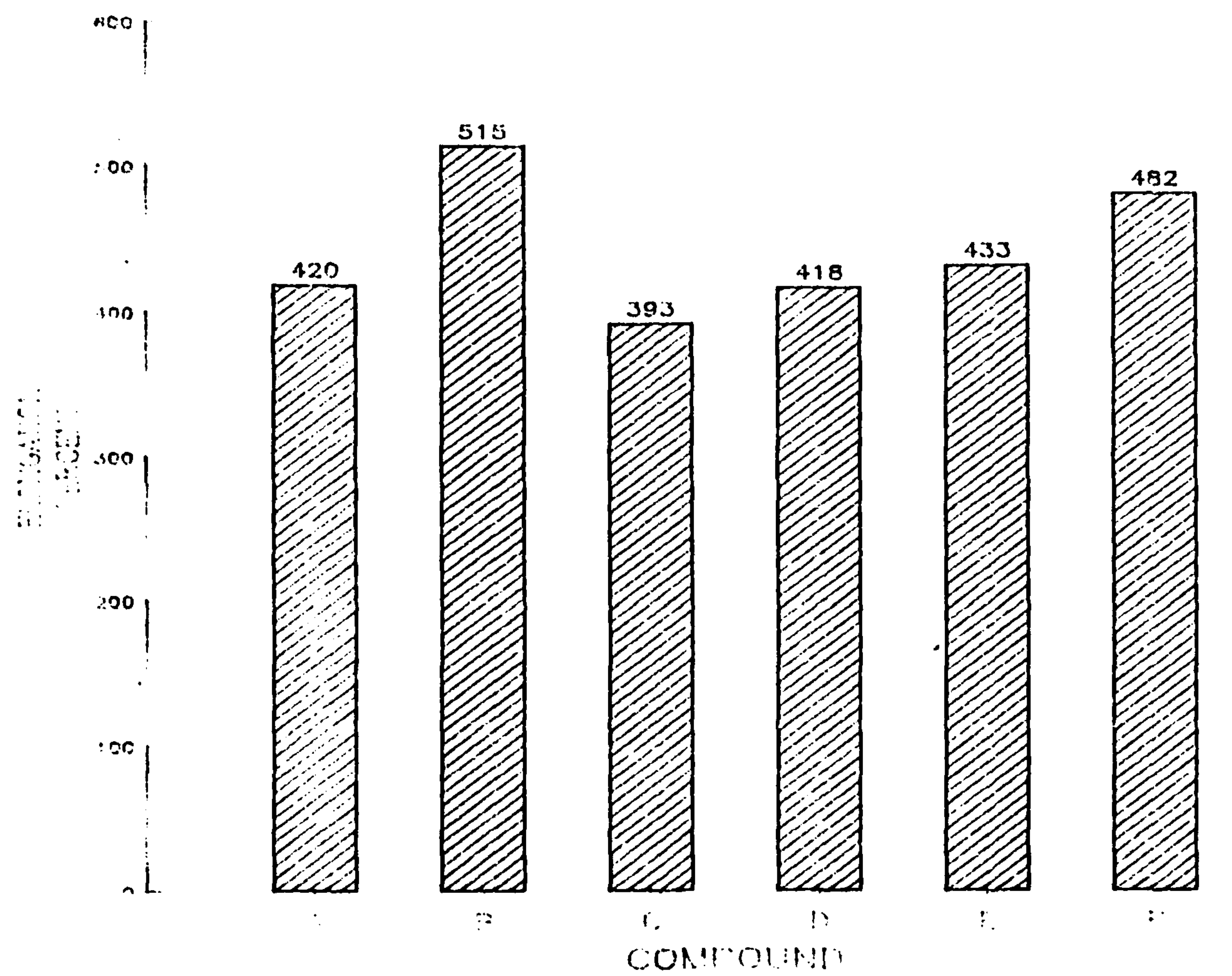

Figure 5-4 ELONGATION AFTER 70/158 F AIR AGE

5.3.4 Tensile, Elongation, Tensile Modulus after 70 hrs/212 degrees Air Age

In a more severe heat-aging test, specimens were aged for 70 hrs at 212 degrees in accordance with ASTM D573. As seen in Table 5-1 and Figures 5-5 and 5-6, the tensile strength kept after aging ranged from 80 percent to 90 percent. The change in elongation after aging is good for all compounds. Again, all compounds are stable when exposed to 212 degrees air aging.

5.3.5 Original Tear Strength

The tear strengths of the compounds, as determined using ASTM D624, Die B, at 72 degrees and 250 degrees are reported in Table 5-1 and Figure 5-7. The 72 degrees F tear strengths of experimental compounds B thru F show substantial improvement over the values prescribed by Mil-T-11891B. Compound A gives tear values midway between the Mil-T-11891B minimums and the values obtained by the other experimentals.

The hot (250 degrees F) tear values (Table 5-1 and Figure 5-7) for compounds B thru F are good, ranging from 325 lbs/in to 385 lbs/in. Compound A has a hot tear value of 241 lbs/in, about midway between the Mil-T-11891B spec limit of 175 lbs/in and the values obtained from compounds B thru F.

5.3.6 Tear Strength after 70 hrs/212 degrees F Air Age

The tear strengths of the compounds at 72 degrees F and 250 degrees F were measured after aging 72 hrs in a circulating air oven at 212 degrees F per ASTM D573. As with original tear strengths, Die B of ASTM D624 was used. Results are given in Table 5-1 and Figure 5-8.

Retention of tear strength after 70 hrs at 212 degrees F was good both at 72 degrees F and 250 degrees F. Compounds B thru F again yielded the highest tear strength values ranging from 478 lbs/in to 690 lbs/in when tested at 72 degrees F and from 296 lbs/in to 370 lbs/in when tested at 250 degrees F.

5.3.7 Compression Set

Compression set was determined using method B of ASTM D395 after 22 hours at 158 degrees F and 22 hrs at 212 degrees F. The percent compression set values for both conditions are in Table 1.

5.3.8 Low Temperature Brittleness

When tested per ASTM D213, Method A, all compounds passed the brittleness test at -40 degrees F.

5.3.9 Ozone Resistance

The compounds were tested for resistance to ozone in accordance with ASTM D1149 using specimen size specified in ASTM D518, method B. The partial pressure of the ozone in the test cabinet was 50 mPa. The specimens were exposed to the ozone environment for seven days at 100 degrees F. All compounds had a 0 rating (no cracks) when examined under seven power magnification.

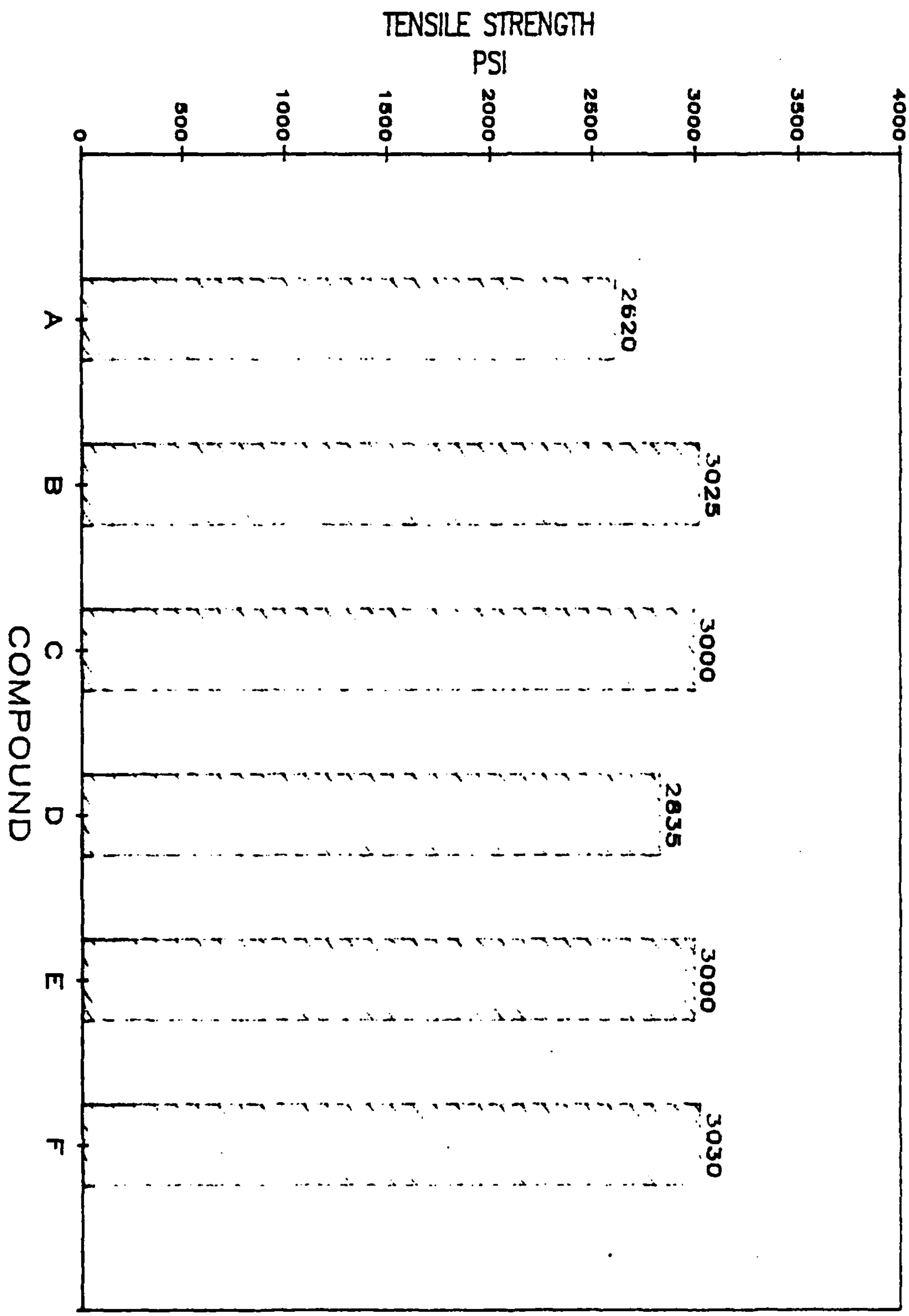

Figure 5-5 TENSILE STRENGTH AFTER 70/212 F AIR AGE

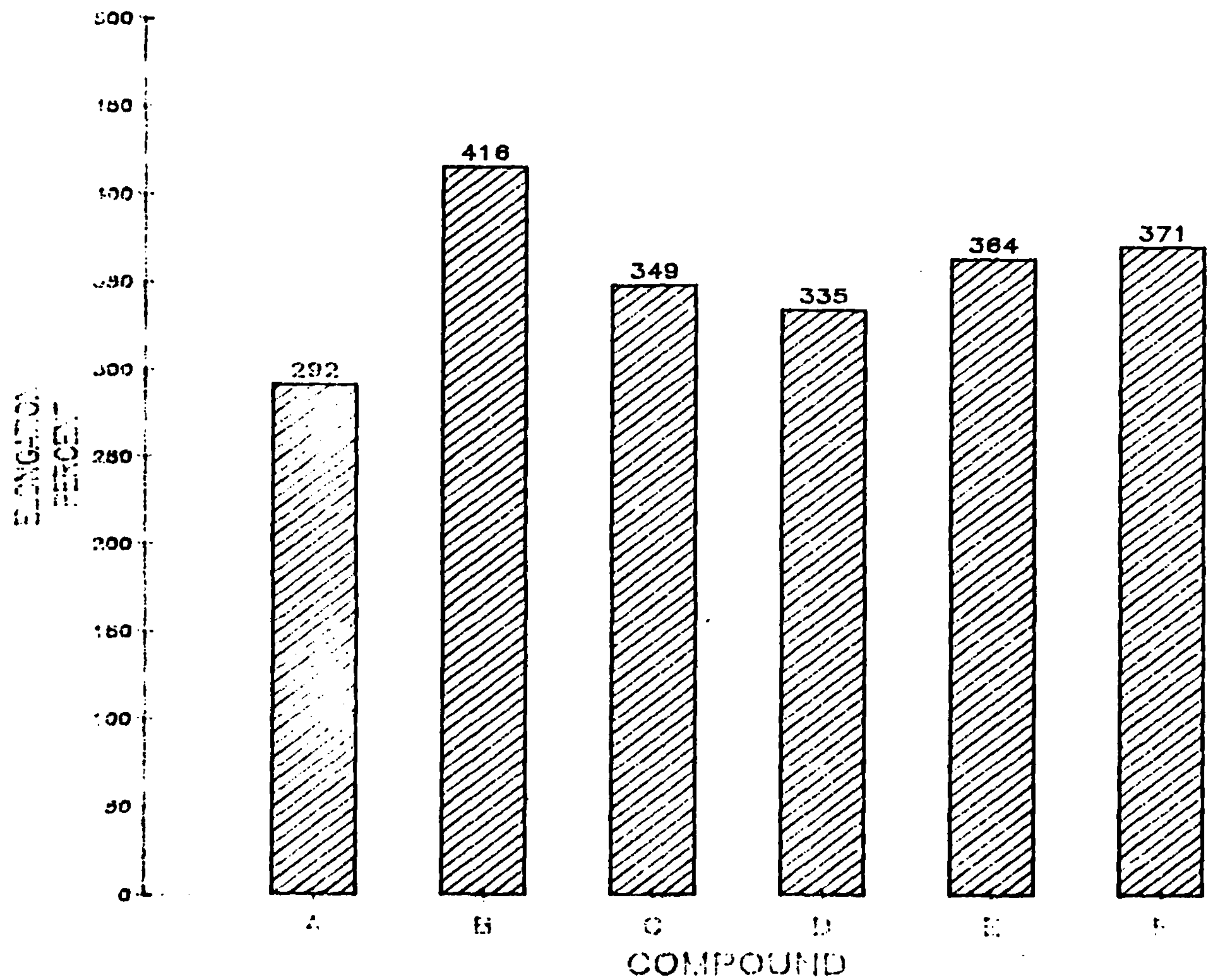

Figure 5-6 ELONGATION AFTER 70/212 F AIR AGE

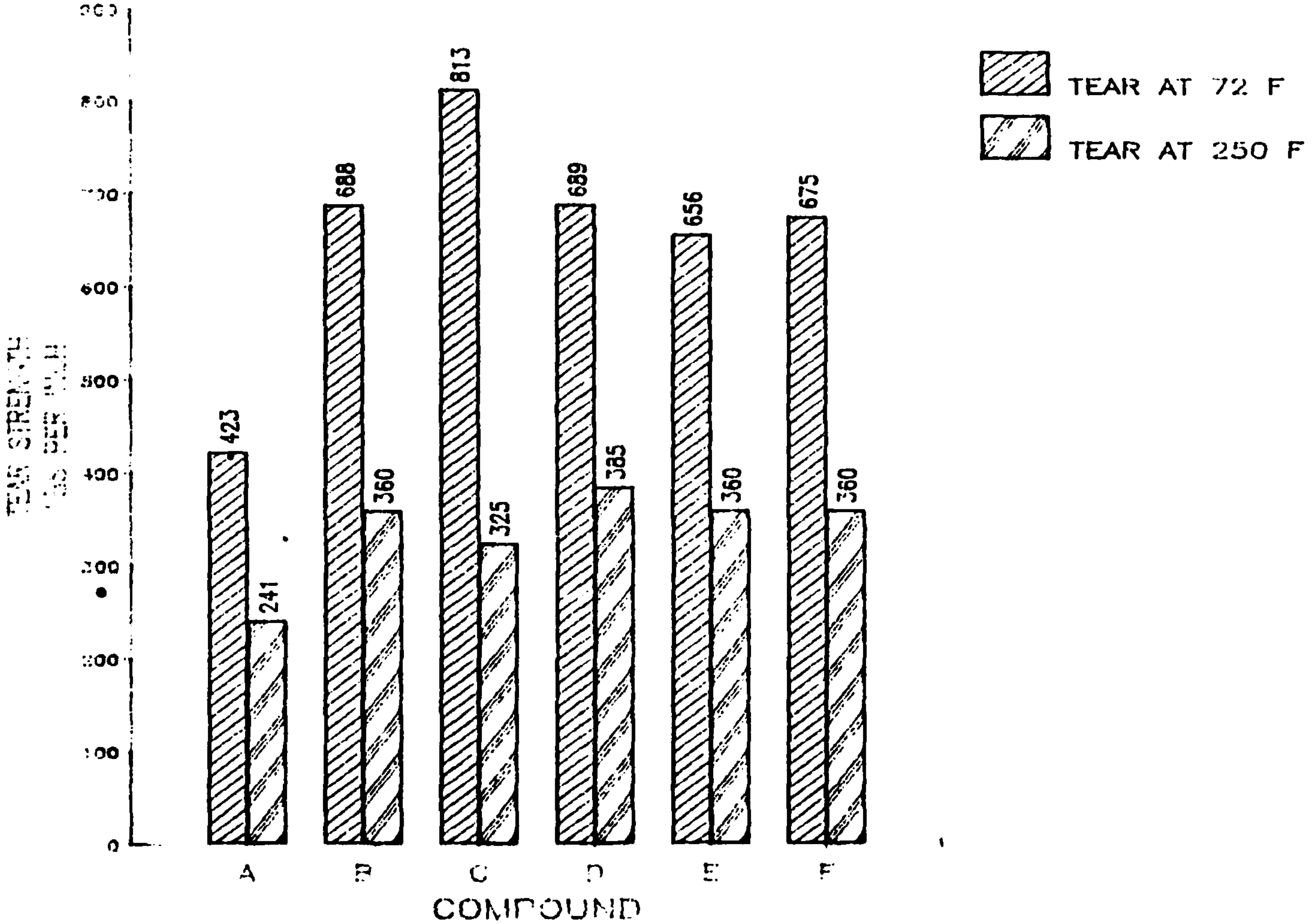

Figure 5-7 TEAR STRENGTH ASTM D624 DIE B
72 F AND 250 F

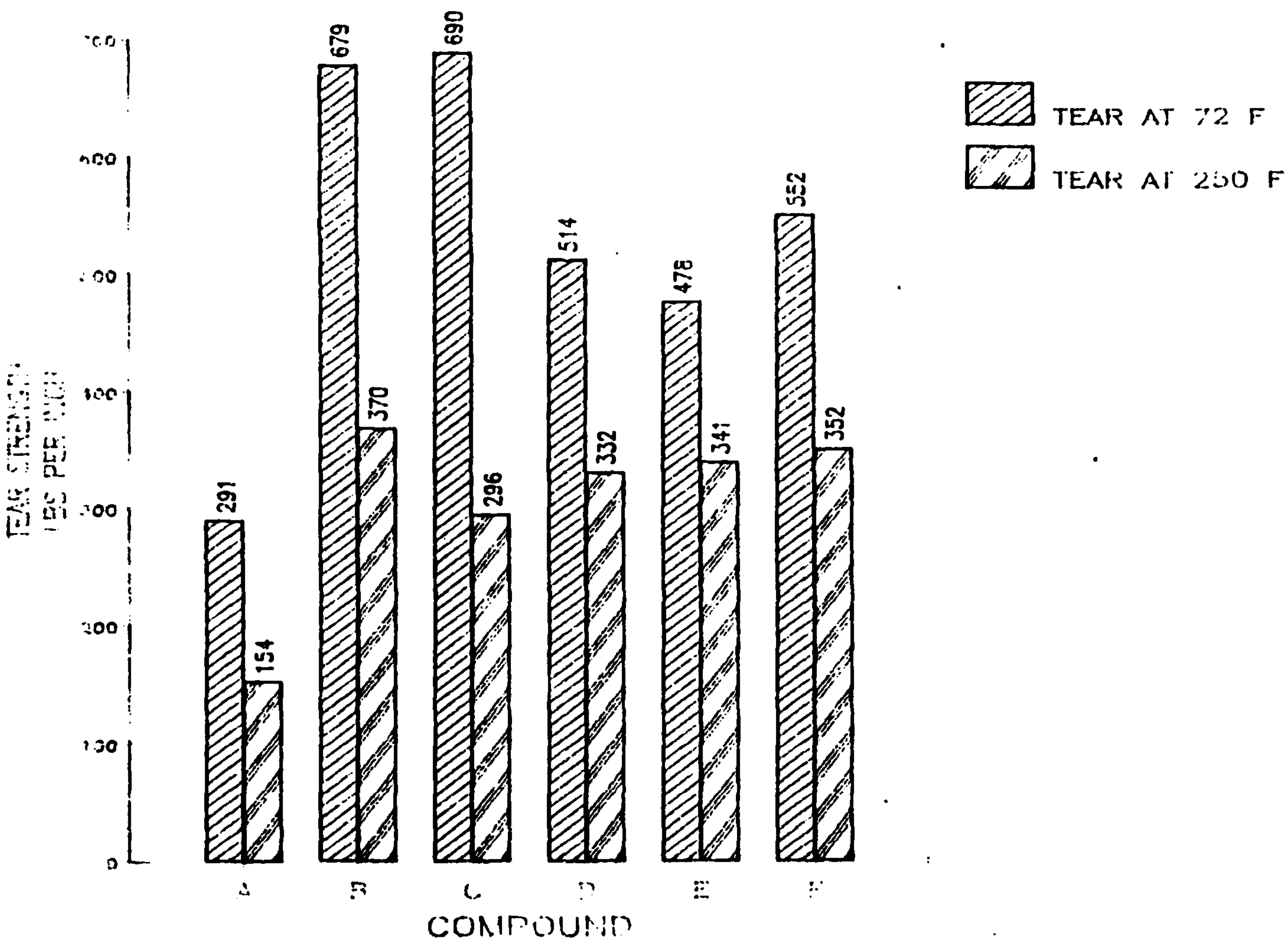

Figure 5-8 TEAR STRENGTH ASTM D624 DIE B 72 F AND 250 F AFTER 70 Hrs/212 F AIR AGE

5.3.10 Goodrich Flexometer Heat Build-up and Blow-out Tests

Each of the compounds was tested for heat build-up and blow-out resistance in accordance with ASTM D623 using the Goodrich Flexometer. Heat build-up was run with 0.175 in. stroke, 143 psi load, 1,800 cycles per minutes and 100 degrees F starting temperature. The heat rise and percent set were determined after 15 minutes. As seen in Table 5-2 and Figure 5-9, the heat build-up of all compounds was low and all had taken low set.

The blow out test was run with 0.175-in. stroke, 483 psi load, 1,800 cycles per minute and 100 degrees F starting temperature. The test was run for 15 minutes or until blow-out, whichever occurred first. Results are in Table 5-2 and Figure 5-10. The only compound which blew out was compound A, which did so after 11 minutes at a temperature of 422 degrees F (T = 322 degrees F). The remaining compounds had heat build-up ranging from 114 degrees F for compound C to 250 degrees F for compound B. The percent set ranged from 12.1 percent for compound C to 20.8 percent for compound B.

5.3.11 Taber Abrasion

Taber abrasion was run per ASTM D3389 using samples cut from standard ASTM-cured sheets. The percent change in thickness and weight was measured after 10,000 cycles using a 1,000 gm. weight and H-22 stone as the abrasive. As seen in Table 2, the loss in thickness and weight is minimal for all of the compounds tested. Compound A had the best abrasion resistance with only a 1.3 percent loss in thickness and a 0.4 percent loss in weight.

5.3.12 Pico Abrasion

Abrasion resistance was measured using a Pico Abrader in accordance with ASTM D2228. The abrasion index for each compound is given in Table 5-2. Though the order is different with respect to the compounds relative abrasion resistance as compared to the results obtained in Taber Abrasion, the abrasion index for all of the compounds is good.

5.3.13 Crack Growth - DeMattia Flexing Machine

Using a pierced sample, the number of cycles required to reach a crack length of 0.75 in. was determined. The method used was ASTM D813.

On Table 5-2, there is a fairly wide variation in the number of cycles required to reach 0.75 in. crack width. Compound A had the lowest value with 56,880 cycles and compound C had the highest value with 176,960 cycles.

This test gives a general indication of crack growth resistance of the compounds

Table 5-2 FLEXOMETER AND ABRASION TEST RESULTS

Goodrich Flex	A	B	C	D	E	F
Heat Build-up ΔT (Degrees F)	83	62	49	48	61	71
Percent Set	3.9	1.4	1.4	1.1	1.7	1.8
Blow Out ΔT (Degrees F)	B.O.	250	114	170	168	162
Abrasion Tests						
TABER 10,000 cycles						
Thickness Loss (Percent)	1.3	4.1	3.0	2.3	3.5	2.8
Weight Loss (Percent)	0.4	1.2	0.7	0.7	0.8	0.9
Pico Abrasion Index	98	87	111	120	125	127
Flex Tests						
DeMattia - Pierced						
Cycles to .75 in. crack	56,880	82,160	176,960	132,720	132,720	132,720
Ross Flex (50,000 cycles)						
Original	1.9	1.1	1.0	1.0	1.0	1.4
Aged 70 hrs/212 degrees F	7.9	1.4	1.3	1.1	1.4	1.6

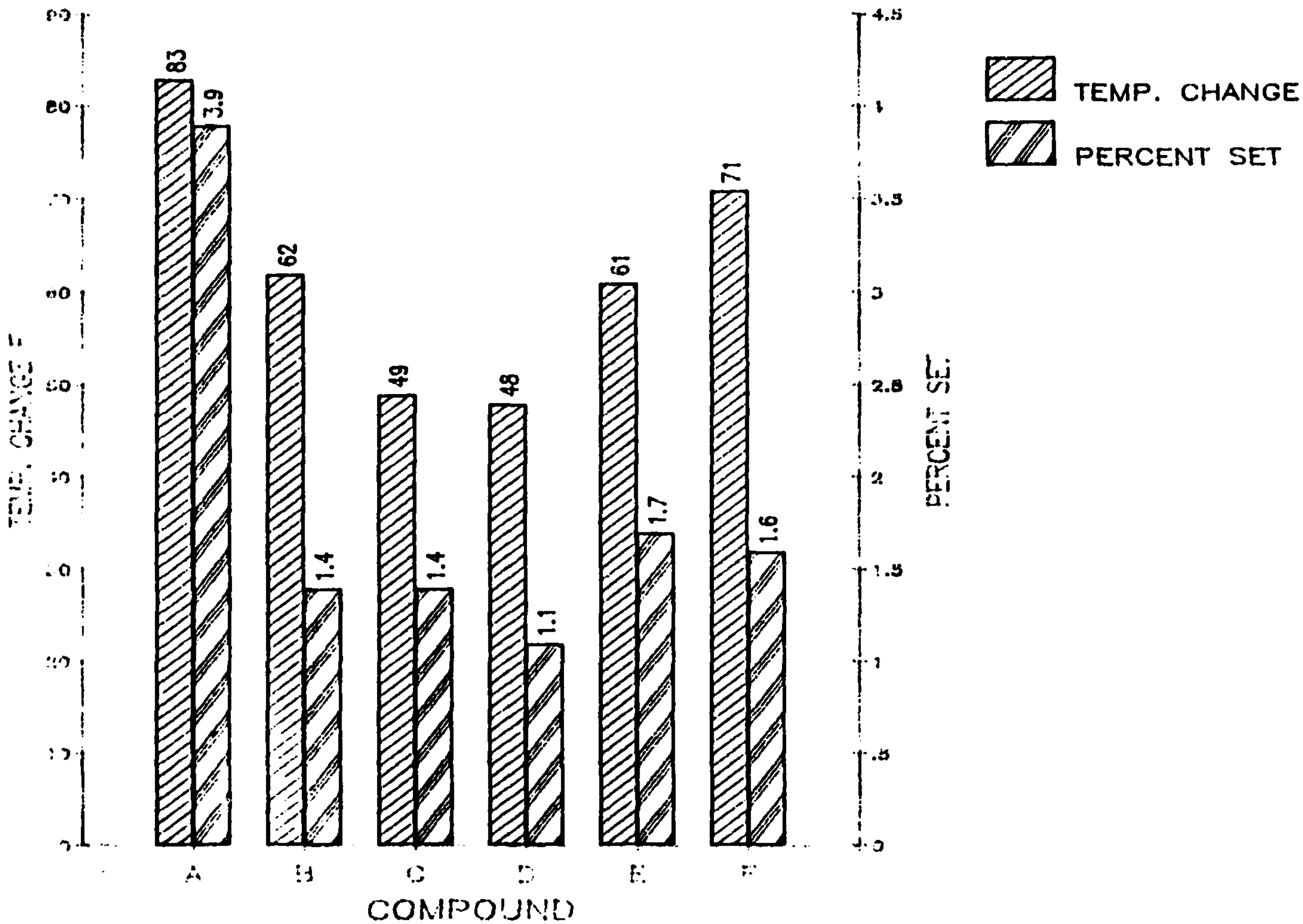

Figure 5-9 GOODRICH FLEX HEAT BUILD-UP
143 PSI, 100 F, .175 IN. STROKE,
15 MIN.

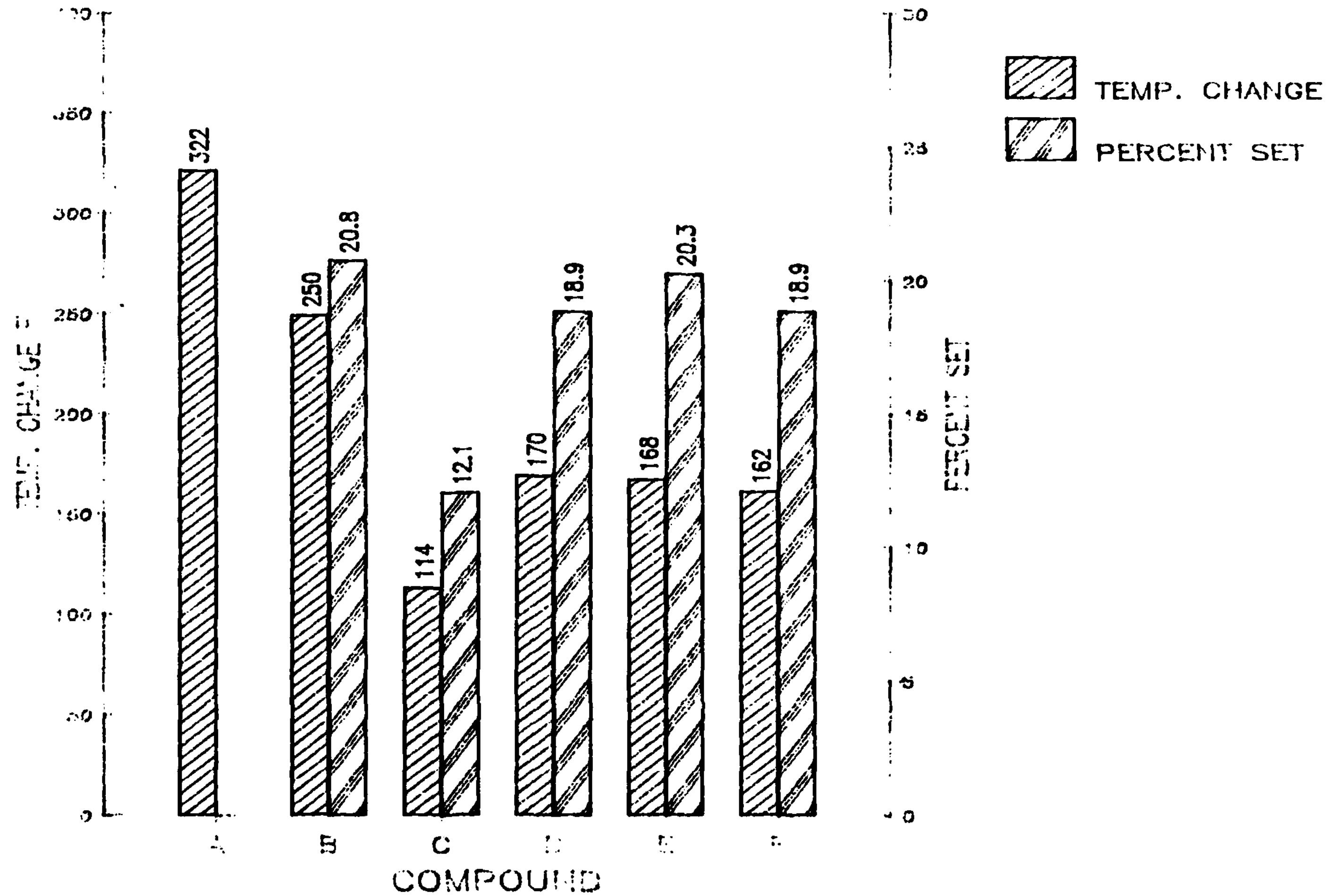

Figure 5-10 GOODRICH FLEX BLOW OUT TEST
483 PSI, 100 F, .175 IN. STROKE,
15 MIN.

SAMPLE A BLEW OUT @ [illegible] MIN.

5.3.14 Ross Flex

The cut growth resistance of the compounds was also determined using the Ross Flexing Machine, ASTM D1052. Testing was done on unaged samples and samples aged in a circulating air oven for 70 hrs, at 212 degrees F. The samples were rated after 50,000 flex cycles on a scale from 1.0 to 10.0. A rating of 1.0 shows no cut growth and a rating of 10.0 shows complete crack through of the sample.

The results are presented in Table 5-2. All of the compounds did well when unaged samples were flexed. After aging, however, compound A had considerable cut growth while compounds B thru F had little cut growth.

5.4 Compound Evaluation

As seen on Table 5-1 and Table 5-2, and Figures 5-1 thru 5-12, compound A has considerably different properties than compounds B, C, D, E and F. In laboratory testing, compound A gives lower tear strength, tensile strength, flex life and blow out resistance. This compound was chosen for submission to TACOM because it represents a compounding approach totally different from compounds B thru F. Though the results obtained in the lab for most properties are not outstanding, this compound may have field test benefits which do not show up in laboratory tests.

Compounds B, C, D, E and F typically have high tensile strength, good tear strength at room temperature and elevated temperature, good stability during aging, good blow out resistance, as measured by the Goodrich Flexometer, good abrasion resistance and good cut growth resistance. Of particular interest for tank track applications is the high tear resistance, good aging characteristics, and good cut growth resistance of these compounds. The strength of the compounds in these areas should translate into better cross-country performance of tank track and corresponding longer life.

Though laboratory test results are similar for compounds B thru F, these compounds represent different compounding approaches. Each of the compounds should be further evaluated to find their relative merits in field testing.

5.5 Fabrication

Sixty T-156 blocks were prepared using normal mixing, preparation and curing methods. All of the blocks used SM8611 on the roadwheel side. Ten blocks each were prepared using the six experimental compounds. No special handling equipment would be required to produce any of these compounds in production volumes.

5.6 Shipping

Ten T-156 blocks of each compound were sent to U.S. Army Tank Automotive Command, Warren, Michigan.

DISTRIBUTION LIST

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